Army Science & Technology

Power and Energy Portfolio Overview

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DESIGN • DEVELOP • DELIVER • DOMINATE
SOLDIERS AS THE DECISIVE EDGE

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Power and Energy

- Power and Energy S&T is a subset of the total Army S&T investment

- There are various ways of looking at the Power and Energy S&T Efforts:
  - S&T portfolios
  - Operational Energy categories
  - Technology Decomposition

- This briefing will provide examples of how Power and Energy is characterized, and a layout of current S&T efforts

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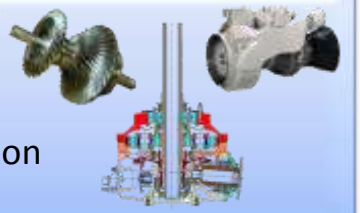
Power and Energy by S&T Portfolio
An example from the Air Portfolio

Engines & Drive Trains Sub-Portfolio

Goal: Provide increased power density to meet vertical lift operation requirements while reducing fuel usage

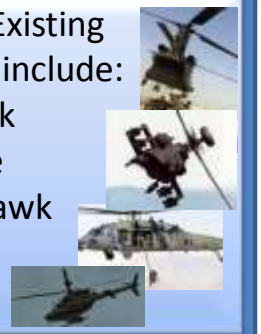
S&T Major Efforts include:
- 3000 shp turbine engine
- 7000 shp turbine engine
- Advanced high power density transmission



Near-term Goals:
- Develop turbine engine with 25% reduced fuel burn and 35% reduced production and maintenance costs (medium fleet)
- Develop turbine engine with 35% reduced fuel burn and 45% reduced costs (heavy fleet)
- Develop high power density transmission with 55% increased hp/wt and 35% reduced production and maintenance costs

Mid/Far-term Goals:
- Develop turbine engine with broad, high efficiency operating speed envelope
- Develop lightweight, durable multi-speed/variable speed transmission to provide variable output speed

Legacy/Existing Systems include:
- Chinook
- Apache
- Blackhawk
- Kiowa



Internal Stakeholders:
- AMRDEC
- ARL
- VAATE

External Stakeholders:
- PEO-Avn, Platform PMs
- PM-ASE
- G-3/5/7 Aviation, G-8
- Navy/USMC
- TRADOC

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Operational Energy

Operational energy.— The term "operational energy" means the energy required for training, moving, and sustaining military forces and weapons platforms for military operations. The term includes energy used by tactical power systems and generators and weapons platforms.

Source: United States Code Title 10 › Subtitle A › Part I › Chapter 4 › § 138c

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Operational Energy Domains

Dismounted Maneuver

Capability Priorities:
- Increased Mobility, lethality
- Decreased Resupply and Operational Interruptions

Trend:
- More Systems = Net increase in power demand
- Networked Communications to the Soldier level

Soldier-Worn Integrated Power Equipment System (SWIPES)

Mounted Maneuver

Capability Priorities:
- Flexibility for rapidly changing operating environment
- Endurance/sustainability

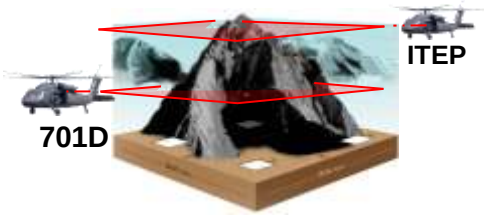
Trend:
- Diversification of threats
- Proliferation of onboard systems
- Networked energy concepts

Integrated Starter-Generator (ISG)

Air Maneuver

Capability Priorities:
- 424 Km Radius of Action without Refuel
- Operational coverage 6K/95°

Trend:
- Extended distances, remote locations
- Increasing Soldier load



Improved Turbine Engine Program (ITEP)

Contingency Basing

Capability Priorities:
- Interoperate with systems, Soldiers, partners
- Increase efficiency to provide more resources for operations

Trends:
- Extended operations – quality of life improvements
- Increased use of contracted support

Microgrids

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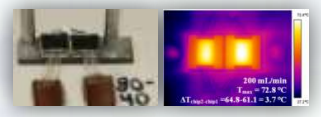
Army Power and Energy S&T supporting Operational Energy Domains

Multi-chip manifold microchannel coolers



Wide Band Gap Materials (SiC)

Basic Research

- Underlying technology basics that will support all domains.
- Examples: SiC for power electronics, wireless power transfer, alternative power conversion, thermal control

Li-Air
Li-rechargeable

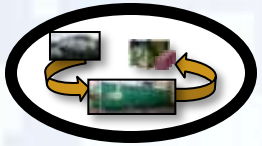
Electrotextiles

On Soldier Helmet to Source Off-Soldier Charging

Integrated Energy Harvesters

Dismounted Maneuver

- Electrochemical power sources for longer lasting power
- Wearable Power and recharging capability for improved mobility
- Alternative energy to reduce logistics burden



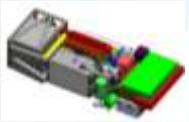
Waste to energy

Architectures for smart grids

Variable speed Multi-fuel gensets

Contingency Basing

- Generators with multi-fuel use
- Improved efficiency equipment, and energy efficient shelters
- Intelligent power management



Electric Power for Silent Watch

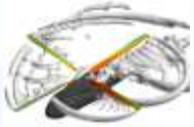
Integrated Starter Generator

Synthetic and Renewable Fuels leading to fuel agnostic engines

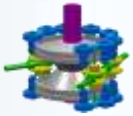
Mounted Maneuver

- Power generation and energy storage
- Power and thermal management
- Fuels

"Brick" batteries for EM Armor and DE Weapons



Reconfigurable Rotor



Future Advanced Rotorcraft Drive System

Air Maneuver

- Advanced turbine engines
- High efficiency drive systems
- Advanced Rotors

Future Advanced Turbine Engine

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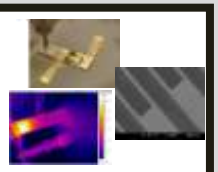
Power & Energy S&T Taxonomy

Power and Energy Technology

Power Generation & Conversion	Energy Storage	Power Control & Distribution	Thermal Management	Fuels & Lubricants
Fuel Cells	Primary Batteries	Power Switches & Electronics	Heating & Cooling	Tactical Fuels
Mechanical Conversion	Rechargeable Batteries	Power Converters & Inverters	Sub-System Thermal Management	Packaged /
Alternative & Renewable Energy Conversion	Reserve Batteries	Power Distribution	Power Electronics Cooling	Other Fuels
Micro Power	Capacitors	Intelligent Power Management	Heat Transfer Technology	Fuel Generation
Electro-Mechanical Conversion				Lubricants
				Fluids
				

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Power Generation & Conversion

Goal

- High density, fuel efficient, compact portable power
- Integrated systems through intelligent power management
- Improved efficiency
- Energy harvesting
- Use of logistics fuel
- Scalable power for autonomous system

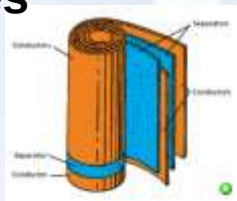
Approach

- Fuel Reformation and alternative fuels
- Fieldable renewable / alternative energy
- Integrated power management
- Improved conversion efficiencies (ex: TPV, solar, and micro-combustors)
- Harvesting for low power & micro power

Improve alternatives & conversion to extend forward capabilities

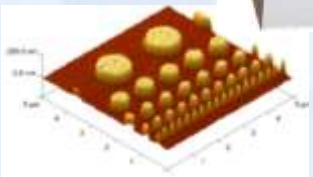
Energy Storage

Primary & Rechargeable Batteries



Munition Batteries

Capacitors & Novel Storage



Form Factor & Design

Goal

- ***Rechargables:*** Higher energy & power densities; conformal shapes, rapid recharge, safer extremes
- ***Primaries:*** High density large format; temp range
- ***Reserves:*** Active materials, nano foil initiation
- ***Capacitors:*** Pulse and high temp materials

Approach

- Incremental, long term improvements: densities
- Trade offs: temp range, safety, scaling
- New materials: nanophase, nano structured, bio inspired
- Analysis & synthesis: role of multiscale modeling

Way Ahead

- Nanotechnology application to design
- Highly conductive electrolytes
- Rapid recharging
- Hybrid storage, super capacitors
- Thin, conforming form factors

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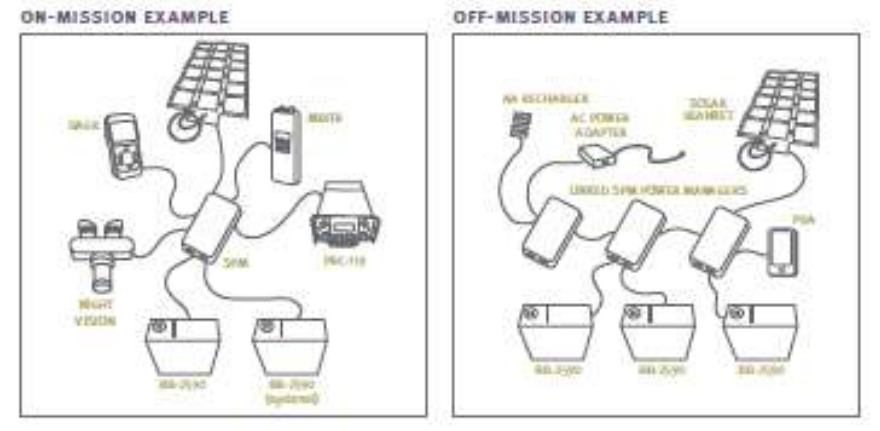
Power Control & Distribution



Soldier-borne power manager

Base Camp intelligent power management

Challenge

- Increasing wide band gap (WBG) power electronics
- Device costs & manufacturing
- Microgrid integration for operational energy fuel reduction
- Scalable, mobile integrated power management (IPM) for Soldiers and platforms
- Load & demand management
- Interfaces, scaling, standards
- Seamless power transfer (wireless)

Way Ahead

- Advanced WBG devices, passives, packaging for high temp, high power electronics
- Architecture. control & integration for legacy & future gensets,
- Smart Battlefield Energy on-demand SmartBED IPM for bases, platform, and Soldiers

Scalable, robust and reconfigurable power systems via intelligent power conditioning, control & distribution

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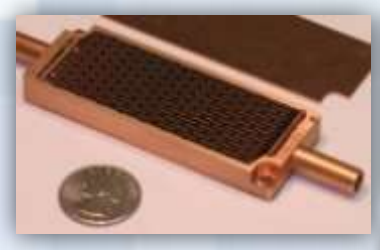
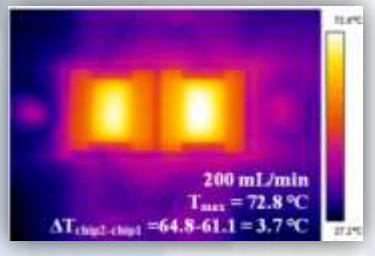
Thermal Management

Shelter Insulation



Multi-chip manifold microchannel coolers



Issues and Observations

- Intelligent cooling may be a means to continue to address thermal load management

Path Forward

- Combined cycle solutions
- Energy recapture
- Integrated generation / environmental control
- Microchannel, 3D electronics packaging and phase change cooling
- Advanced radiator and cooling fan designs
- Advanced Shelter and Platform heating, cooling, and heat load reduction
- Compact thermal solutions to reduce the size & weight of power systems

Novel Approaches to Reducing Thermal Load

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Fuels

EMERGING ALTERNATIVE FUELS MARKET

- DOD
- DOE
- Industry
- Academia
- Fuel Producers
- Equipment OEMs
- Other Government Agencies
- Standards Development Organizations

Market Connection

- Fuels: process technology, data, test volumes
- Engines: combustion/fuel injection technology
- Market: regulations, policies, initiatives

Goal: **Develop fuel specs and qualify new fuels to ensure suitability for use in ground equipment.**

Goal: **Develop engines more adaptable to changes in fuel quality/supply.**

Fuel / Component Evaluations

Engine Evaluations

System Evaluations

Fuel Qualification Process for approval of new fuels

Wayne State University Photo courtesy of N. A. Henein, WSU

Self-adjusting engine operation with changes in fuel quality to maintain desired engine performance

Acceptance of alternative fuels for use in ground vehicles/equipment.

WebPortal for Army wide Industry Engagement

Defense Innovation Marketplace

http://defenseinnovationmarketplace.mil/armyInformation.html

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Providing Soldiers Technology Enabled Capabilities

MAINTAINING A LEADING EDGE IN TECHNOLOGY